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Report developed under SBIR contract for topic N93-084. In Phase I of this project, we explored several different approaches to Near-Real-Time Data Fusion (NRTDF), and in Phase II we developed the most promising architecture into a prototype NRTDF system. The system automatically extracts the maximum amount of information and produces the best possible tactical picture from the available data by accurately processing all relevant target data in near-real-time. In addition, we demonstrated that this system was capable of fusing large amounts of data in near-real-time using multiple-hypothesis and non-Gaussian data fusion techniques.

As part of the project, with additional support from NAVAIR (PMA-299), we also developed a SH-60R Decision Support System Testbed (DSST) based on NRTDF.

The DSST allows the operator to (1) set up a scenario, with the desired friendly, neutral, and hostile platforms, (2) feed the contacts produced by the friendly sensors into NRTDF, (3) produce a common tactical/operational picture using NRTDF, and (4) utilize an operationally oriented, "unbiased", and "honesty inducing" metric to measure the difference between the ground truth data and the common tactical/operational picture. We also developed a commercial version of the NRTDF system for use in transportation, manufacturing, retail, and security applications.

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FINAL REPORT MEMORANDUM

To: Mr. James P. Lynch, III
Naval Surface Warfare Center

From: W. Reynolds Monach

Subject: Final Report Memorandum for Contract # N00178-95-C-3073, Near-Real-Time Data Fusion, Phase II

1. Overall Description

Under certain time stressing situations, there is a need to fuse a large amount of data in a very short time. Such situations would include anti-ship missile defense, terminal homing, identification, kill recognition, and the like.

In Phase I of this project, we explored several different approaches to Near-Real-Time Data Fusion (NRTDF), and in Phase II we developed the most promising architecture into a prototype NRTDF system. The system automatically extracts the maximum amount of information and produces the best possible tactical picture from the available data by accurately processing all relevant target data in near-real-time. In addition, we demonstrated that this system was capable of fusing large amounts of data in near-real-time using multiple-hypothesis and non-Gaussian data fusion techniques.

As part of the project, with additional support from NAVAIR (PMA-299), we also developed a SH-60R Decision Support System Testbed (DSST) based on NRTDF, which is illustrated in Figure 1.

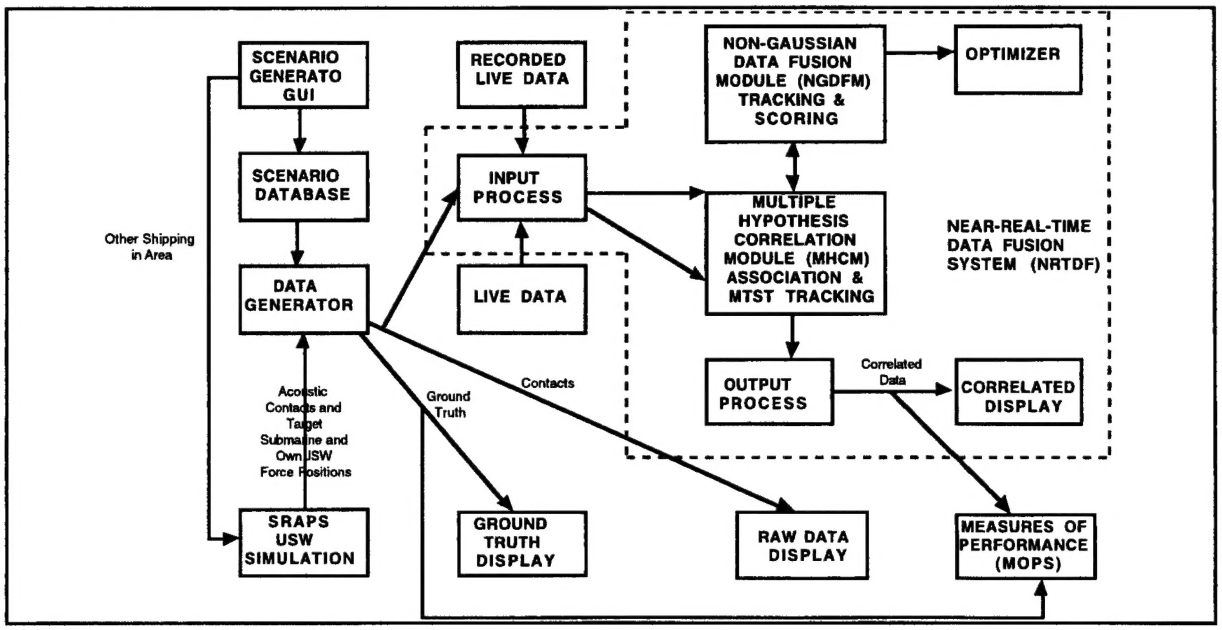

Figure 1. Decision Support System Testbed (DSST)

The DSST allows the operator to (1) set up a scenario, with the desired friendly, neutral, and hostile platforms, (2) feed the contacts produced by the friendly sensors into NRTDF, (3) produce a common tactical/operational picture using NRTDF, and (4) utilize an operationally oriented, "unbiased", and "honesty inducing" metric to measure the difference between the ground truth data and the common tactical/operational picture.

We also developed a commercial version of the NRTDF system for use in transportation, manufacturing, retail, and security applications.

2. Specific Project Technical Results

We developed a NRTDF system which:

- Handles high data rates, on the order of 1000 contacts per second
- Includes new high speed communications modules to allow NRTDF to transfer data between Unix workstations at data rates greater than 1000 contacts per second
- Includes an input process which determines which correlation processes may be used and how incoming data will be processed
- Includes a track update process which automatically updates tracks, thus moving a significant portion of the multiple-hypothesis module workload to another processor
- Includes, in the full database correlation process, a new multiple-hypothesis correlation algorithm which greatly speeds up the process of determining which contact-to-track associations are feasible by efficiently partitioning the tactical database

- Includes, in the full database correlation process, a technique for allowing the Non-Gaussian Data Fusion Module of NRTDF to take advantage of any number of available Unix processors (currently implemented on SUN and HP workstations)
- Operates in near-real-time
- Processes all relevant threat data:
  - "positive" data from sensor contacts and intelligence sources
  - "negative" information from sensors operating and not obtaining contacts in areas of interest
  - target motion information
- Processes this data as accurately as possible, using:
  - multiple-hypothesis algorithms
  - Bayesian inference methods
  - Gaussian (Kalman filter) and non-Gaussian (high fidelity Monte Carlo) tracking algorithms

We also developed a scenario data generator with a graphical interface to allow the user to easily develop test scenarios for NRTDF (this interface is shown in Figure 2).

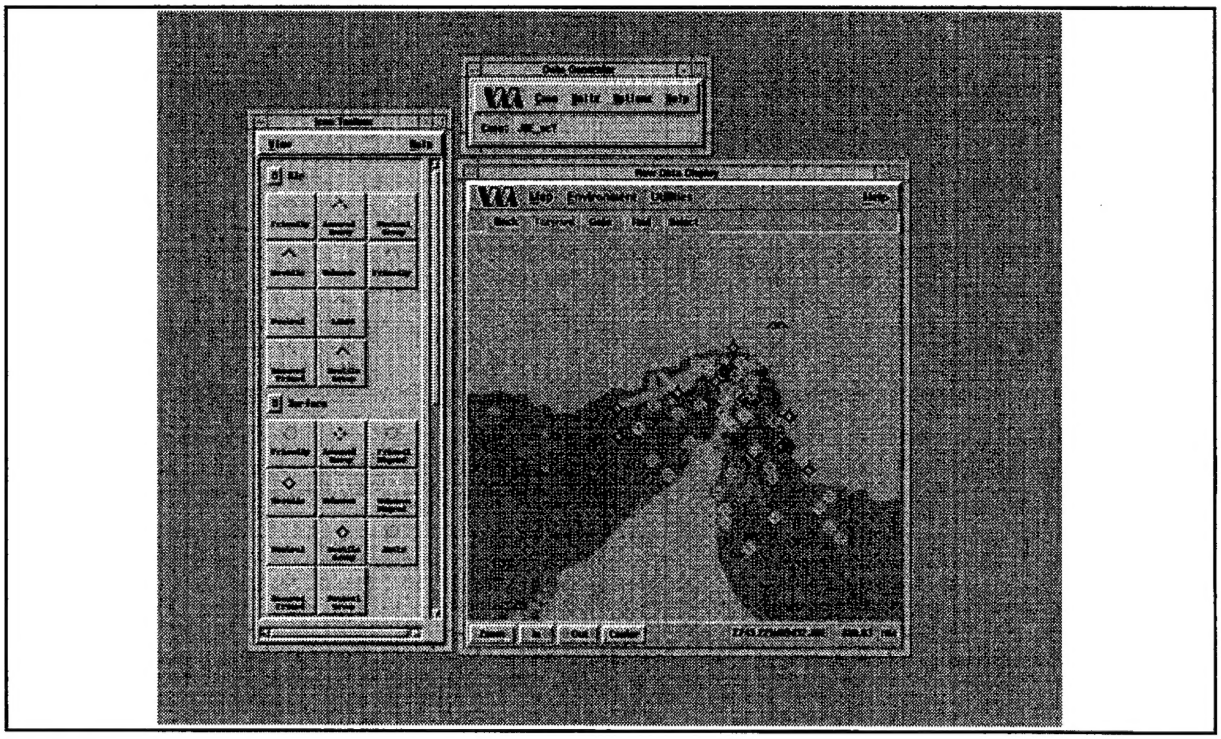

Figure 2. DSST Data Generator Graphical User Interface

In addition, we:

- Tested NRTDF using both simulated and actual sensor data (a sample raw and correlated data display is shown in Figure 3).

- Developed and tested a Measures of Performance (MOPs) Module which allows the user to analyze the difference, both kinematic and non-kinematic, between ground truth and the tactical database produced by NRTDF (a sample graphical metric display is shown in Figure 4).

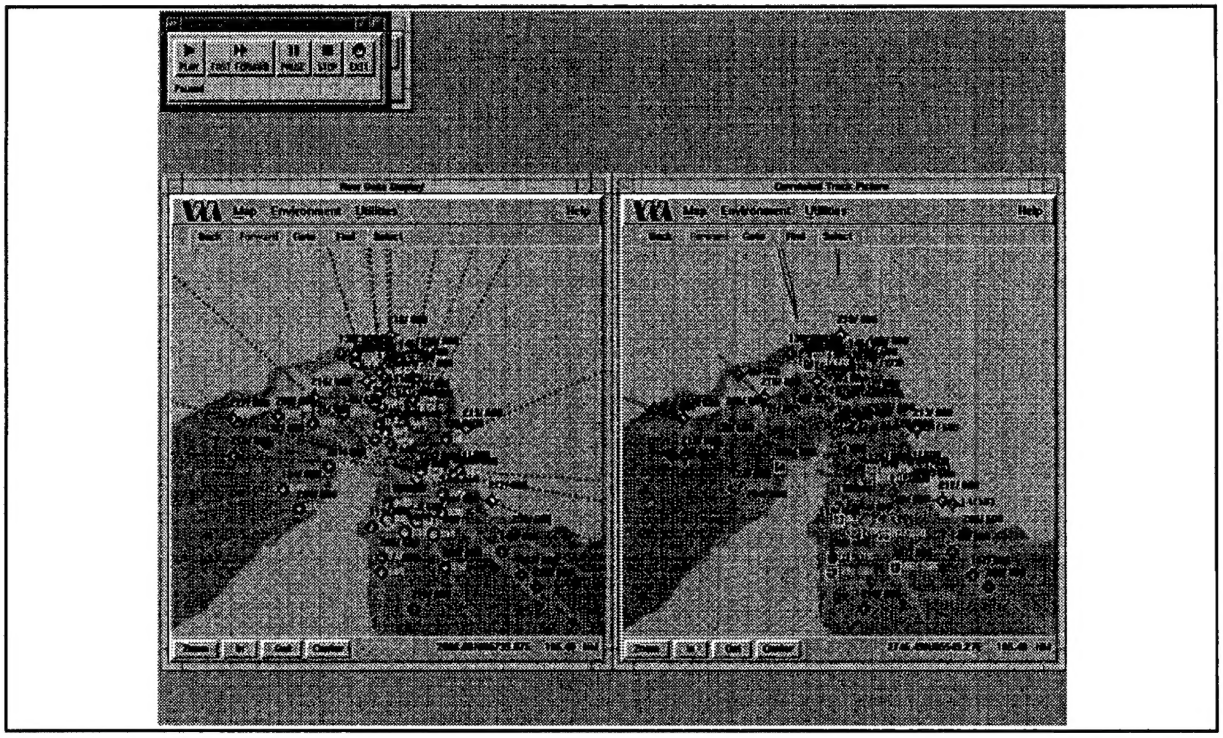

Figure 3. GCE/NRTDF Example Raw and Correlated Data Display (Scenario is SH-60R Surveillance of Strait of Hormuz)

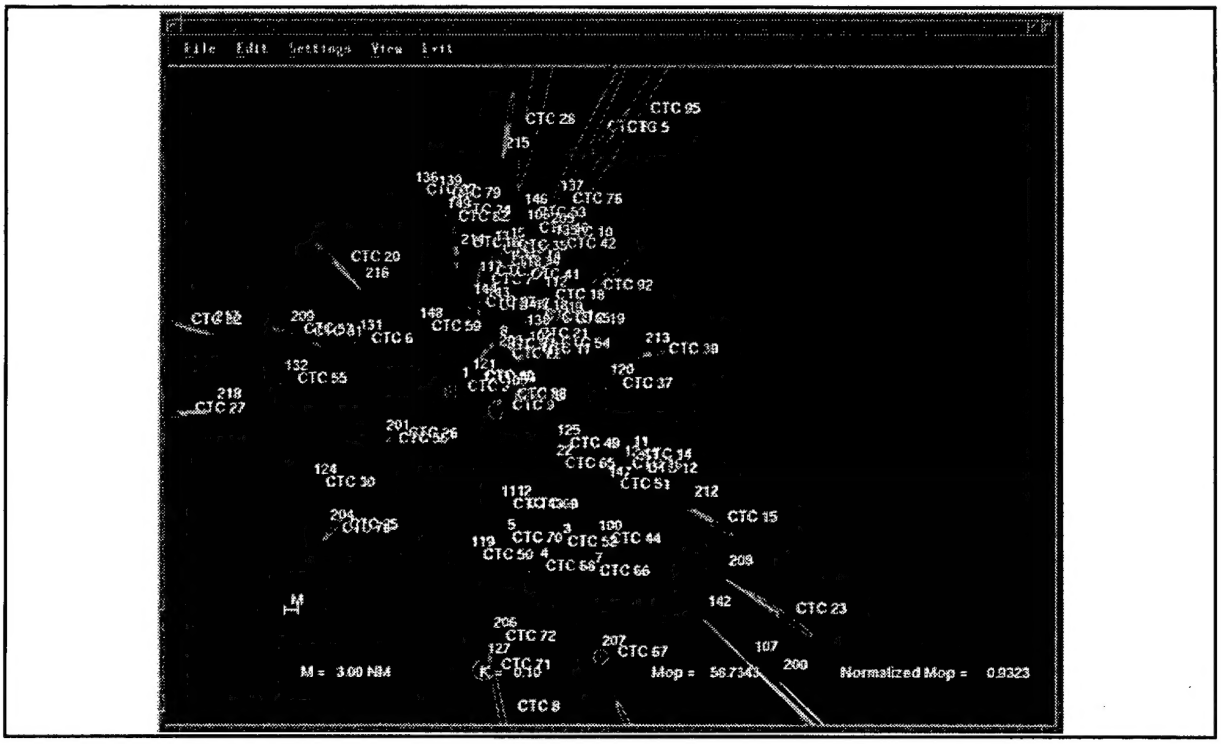

Figure 4. Graphical DSST Metric Output Example

We also developed a commercial version of the NRTDF system (Factory Tracker™) for use in manufacturing, retail, and security applications and tested it with video data obtained from industrial test sites.

3. Navy, DoD, and Commercial Transition Results

Used DSST, working with John Hopkins University-Applied Physics Laboratory, to study DSS/SH-60R integration issues for NAVAIR.

Used the DSST as the basis for the Acoustic Mission Planning (APM) module which will be integrated into the SH-60R combat system and the SH-60R shipboard mission planning system.

Developed a SPY-1 radar energy resource allocation algorithm for tactical ballistic missile defense based on NRTDF resource allocation algorithms.

Developed a version of NRTDF for tracking land targets for NSWC-DD/U.S. Marine Corps.

Designed a NRTDF based resource allocation system for use in counter-narcotics operations for JIATF-East.

W. Reynolds Monach